Sanders instruction manual

V.S.W.R. INDICATOR

AND SELECTIVE AMPLIFIER

W. H. Sanders (Electronics) Limited

Gunnels Wood Road · Stevenage · Herts.

A Member of the Sanders Group of Companies

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GUARANTEE

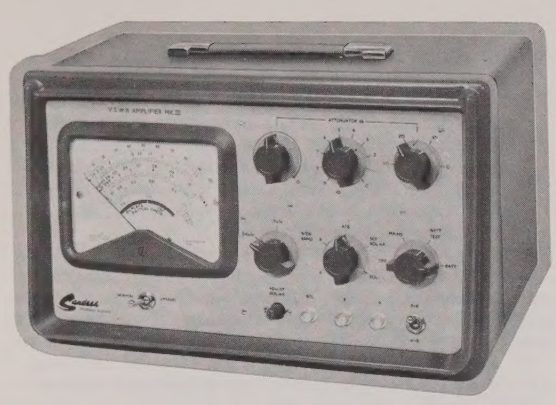
W.H.Sanders (Electronics) Ltd., guarantees each instrument manufactured by them to be free from defects in material and workmanship. Our obligation under this guarantee is limited to servicing or adjusting the instrument and to making good any defective parts thereof. Valves, fuses, batteries, semi-conductors and bolometers are specifically excluded from any liability. This guarantee is effective for one year after delivery to the original purchaser, when the instrument is returned to our factory with transportation charges prepaid, and when upon examination by the Company shall be found to be defective. If the fault has been caused by misuse or malhandling repairs will be billed at cost. In this event an estimate will be submitted before the work is started.

REPAIRS

When returning instruments for repair, or for any other reason, please contact the Company for shipping instructions. To expedite repair service, it is important to provide type number, serial number, and a detailed description of the reason for the return of the instrument.

CHANGES

Because we have a programme of continuous product improvement, specifications noted herein are necessarily subject to change without notice. The Company also reserves the right to make changes in design without incurring any obligation to make the same changes in units previously ordered or to continue the production of instruments conforming to former designs.



V.S.W.R. INDICATOR AND SELECTIVE AMPLIFIER

GENERAL DESCRIPTION

The V. S. W. R. Indicator and Selective Amplifier is basically a low noise, high gain amplifier driving a meter output. The instrument is primarily intended for laboratory use, but, its small size and robust construction make it equally suitable for use in the field.

Provision is made for two inputs from crystal detectors, these can be used independently or together for bridge measurements. A separate input is provided with a d.c. bias supply for bolometer operation.

The amplifier can be made selective at 1000 c/s and 3000 c/s or switched to broad band operation (800-3500 c/s) with only a small loss of sensitivity. The accurate attenuators are adjustable from 0 to 40 dB in increments of 1 dB, and a continuously variable 0-1 dB attenuator is also provided. Attenuator calibration assumes that the input is via a square law detector.

Either a mains a.c supply or internal batteries can be used to power the instrument which has a very low power consumption.

CONCISE DETAILS

Frequency Range:	800 c/s to 3.5 K c/s.
Selective frequencies:	1 K c/s and 3 K c/s.
Selectivity:	100 c/s bandwidth for 1 K c/s operation, 400 c/s bandwidth for 3 K c/s operation.
Sensitivity (normal):	better than 1 μV f. s. d. for selective operation, better than 2 μV f. s. d. for wide band operation.
Sensitivity (expanded scale):	better than 0.4 μV f. s. d. for selective operation, better than 0.8 μV f. s. d. on wide band operation.
Input impedance:	approx. 1000 ohms.
Noise level:	less than 0.1 μV on selective operation, less than 0.3 μV on wide band operation.
Attenuators: Figures assume square law detector. For linear detector, the scales should be doubled.	0 to 30 dB in 10 dB steps ±0.5 dB. 0 to 10 dB in 1 dB steps ±0.2 dB. 0 to 1 dB continuously variable.
Meter scales:	1. Response and d.c. 0-100μA 2. V.S.W.R.,∞ to 1 and 0 to 1 3. V.S.W.R.,∞ to 3 and 0 to 0·33 4. Expanded V.S.W.R., 1·3 to 1 and 0·77 to 1
Meter calibration:	square law.
Bolometer bias:	adjustable from 3 to 10 mA.
Power Supplies:	Mains, 110-120 V or 200-250V, 50-60c/s. Batteries, three Vidor T.6001 or Ever Ready PP1.
Dimensions:	16in. wide x 9in. high x 9in. deep.

OPERATING INSTRUCTIONS

PREPARATION

Mains Voltage

Set the connections on the mains transformer to the appropriate taps, for the local supply.

Fuse

A 250mA fuse is mounted above the mains input socket. If the instrument is to be operated from a 110-120 volt supply, change the fuse for one of 500mA value.

Mains Lead

Fit a three-pin plug to the mains lead, connecting as follows:-

red lead - mains supply - live
black lead - mains supply - neutral
green lead - earth

MEASURING TECHNIQUES

V.S.W.R.

For normal V.S.W.R. measurements the instrument is used in the conventional manner. Either socket A or Socket B may be used for connection to a crystal.

Bridge Applications

If two signals are available from the microwave bench, very small deviations in either of the signals can be accurately measured using bridge techniques. When the two inputs are connected to sockets A and B they complete a bridge network with two primary windings on the input transformer.

Having connected the signals to sockets A and B, proceed as follows:-

1) Switching INPUT SELECTOR to A and B in turn, adjust attenuator on microwave bench until the two signals are indicated as being of approximately the same level on the V.S.W.R. Indicator.

2) Set INPUT SELECTOR to $A \pm B$ and note whether reading rises or falls. If reading rises reverse the position of the A+B/A-B switch.

3) Switch out attenuation in amplifier to increase the reading to a convenient indication.

4) Adjust attenuator on microwave bench to obtain a null on the meter indication.

5) Re-adjust one of the microwave attenuators to a position at which the sensitivity of the indication is adequate for the measurement to be performed, at the same time ensure the working region for these measurements is confined to one side of the null. If necessary the meter indication can be calibrated against an attenuator in the arm in which variations are being measured.

A simpler, but slightly less accurate application of the bridge balance facility, particularly useful in measuring insertion losses above 0.1 dB, is as follows:-

1) Adjust the two signals, as described above, to obtain a null reading.

2) Insert or remove the component, whose insertion loss is to be measured in one arm of the microwave system.

3) Adjust the attenuator in that arm of the system to re-establish the null reading. The difference in the two readings of the attenuator is the insertion loss.

Expanded V.S.W.R.

When a V.S.W.R. of less than 1·3:1 is being measured, a more accurate reading can be obtained by using the expanded scale facility as follows:-

1) Adjust microwave and/or amplifier attenuators to obtain a reading of approximately a for the standing wave maximum.

2) Set NORMAL/EXPAND switch to EXPAND.

3) Proceed as in normal V.S.W.R. measurement but read the red EXPANDED V.S.W.R. scale.

NOTE: Ensure that EXPAND/NORMAL switch is returned to NORMAL on completion of the measurement.

Bolometer Operation

On bolometer operation the bolometer bias must be set in the following manner:-

1) Set the ADJUST BOL. mA control fully anti-clockwise before connecting the bolometer to the BOLOMETER socket.

2) Set INPUT SELECTOR to SET BOL. mA and set ADJUST BOL. mA control to give the required bolometer bias. This is read on the meter scale (F.S.D. = 10mA).

3) Set the INPUT SELECTOR to BOL. and carry out measurements in the normal way.

TECHNICAL DESCRIPTION

INPUT SIGNAL SELECTION

Signal Input A.

This is the normal input socket for straightforward V.S.W.R. measurement. Socket A is also used as the input for the direct measurement of crystal current on the 0-100μA scale of the meter. Switch wafer SW2a connects the signal directly to the meter when the amplifier is switched off, or to switch wafer SW1b when the amplifier is on. SW1b connects the signal to one primary of input transformer T1 when A or A ±B is selected on the INPUT SELECTOR switch SW1.

Signal Input B.

SW1A connects the signal to a separate primary winding of T1, via polarity changeover switch SW7, when B or A ±B is selected on the INPUT SELECTOR switch. SW7 is used only when making bridge measurements to ensure that the signals in the two primary windings are of opposite polarities.

Bolometer

When BOL, is selected on SW1, the bolometer socket is connected by d.c. blocking capacitor C3 and SW1b to the input transformer. A d.c. bias supply is also connected to the socket from the bolometer supply circuit (Page 4).

AMPLIFIER

The signal from the secondary of T1 is taken to a sensitive amplifier, the gain of which is adjusted by means of three attenuators.

The first stage of amplification is provided by the circuit of TR1. This is a conventional low-noise amplifier with feedback from collector to base via R59 to improve linearity. The amplified signal is fed to a 0-30 dB attenuator, formed by resistors R6, R7, R8, R9 and R53. R53 is adjusted on final test to give an accurate 10dB setting, for this reason no value is quoted on the circuit diagram. Switch SW3 permits selection of attenuation in 10dB increments.

If the amplifier was not provided before the attenuator, a lower noise level would be possible, but, with the disadvantage that for small signals the range of attenuation would be limited. On the other hand, high amplification before the attenuator would permit a wide range of attenuation, but at the same time increase the noise level. Thus, the arrangement in this instrument is a compromise to give adequate sensitivity and range of attenuation for normal laboratory use. The high impedance input of emitter-follower, TR2 prevents the amplifier circuits from varying the load on the attenuator.

TR3, TR4 and TR5 are conventional amplifier stages with the collector load of TR5 formed by R26-35 which give 0-10 dB attenuation in 1 dB steps selected by SW4. This is followed by a continuously variable attenuator, RV2, of approximately 1 dB.

After further amplification by TR6 the signal is taken to the 1 Kc/s - 3 Kc/s - WIDE BAND switch which directs the signal through any one of three paths, according to the position selected. These consist of a 1 Kc/s tuned circuit TC1, a 3 K c/s tuned circuit TC2 and a direct connection to emitter-follower TR7. TC1 and TC2 have a Q of 10, giving the amplifier a narrow bandwidth. The high impedance input of emitter-follower TR7 prevents loss of selectivity due to loading of the tuned circuits by the amplifier.

The final amplifier stage, TR8, drives the output transformer T1, which is in its collector circuit.

OUTPUT CIRCUITS

The output of the amplifier is converted to a d.c. signal by bridge rectifier MR3-6, smoothed by R52, C24 and taken to the meter through switch wafers SW1c and SW2c. The EXPAND/NORMAL switch SW5 in its NORMAL position connects R51, R62 and RV4 to shunt the 100μA movement converting it to approximately 250μA f.s.d. In the EXPAND position the shunting resistors are disconnected and a backing-off current is provided from the 7.5V supply via R50 and RV3. The meter is now a 100μA f.s.d. movement and RV3 is preset to give a backing-off current which expands the 1 to 1.3 portion of the normal scale, to cover the whole of the expand scale.

POWER SUPPLIES

Amplifier Power Supply - Mains

The amplifier operates from any 50-60 c/s supply in the ranges 110-120 volts or 200-250 volts, taps on mains transformer T3 provide adjustment to suit the local supply. A 250mA fuse, F1, is fitted for 200-250 volt operation, for 110-120V operation, a 500mA fuse must be fitted.

The 15V at the secondary of T3 is bridge rectified by MR1, smoothed by C15 and dropped through R37, SW2f and parallel resistors R36, R38 (via SW2e) to feed Zener diode MR2 which holds the voltage within ±5% of 7.5V.

Amplifier Power Supply - Battery

Two six-volt batteries are used to provide the amplifier supply when battery operation is selected. The battery supply is taken through parallel resistors R38 and R36 to the amplifier circuit. MR6 holds the supply at a stable 7.5V.

Current consumption is such that at maximum drain, the battery life will be well in excess of 200 hours.

Battery storage is recommended to be limited to nine months.

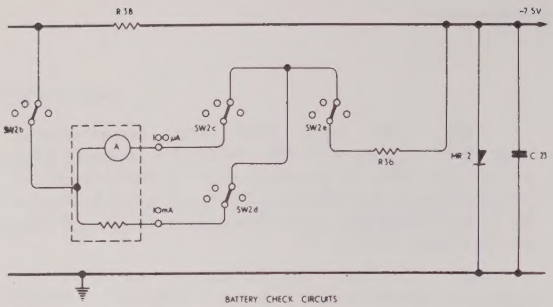


FIG.1

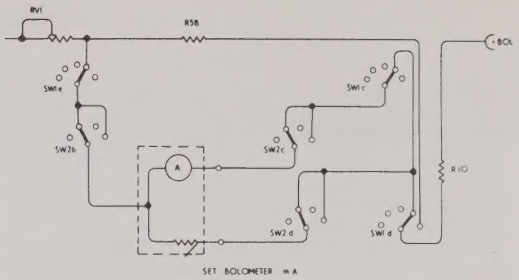


FIG.2

Battery Check

Fig. 1. shows the arrangement of the battery supply to the amplifier when BATTERY CHECK is selected. The meter is converted to a 10mA movement, by the shunt switched in by SW2d, and connected in series with R36. If the current is below 10mA the meter reading indicates that the batteries are exhausted.

Bolometer Bias Supply

The bolometer bias supply is obtained either from the amplifier supply on mains or a separate 6V battery, according to the position of SW2g. This supply is dropped by R61, smoothed by C27, C28, and developed across Zener diode MR7 which limits the supply at this point to 4.5 volts, safeguarding the bolometer against accidental over-voltage.

With SW1 switched to "SET BOLOMETER mA" the bolometer is taken through RV1, the bolometer bias setting control, SW1e and SW2b to the meter. The meter shunt is connected in by SW2c, SW1c and SW2d to give 10mA f.s.d. From the meter the supply is taken through SW1d and R10 to the bolometer, socket on the front panel.

When bolometer operation is selected on SW1 the meter is switched back to read the amplifier output and is replaced in the bolometer supply by R58 to maintain constant bias.

MAINTENANCE

General

As the amplifier is transistorised and all components are generously rated the instrument operates for very long periods with very little attention. The batteries should be checked at regular intervals by means of the battery check facility and changed if they are below standard. If the batteries are not used, remove them and tape the connectors to prevent them shorting.

The EXPAND facility should be checked occasionally in the following manner:-

1. Set mechanical zero of meter.
2. Set controls as follows:-

   Attenuators to 20dB.
   Frequency Selector to WIDE BAND.
   Input Selector to A.
   Supply Selector to MAINS or BATTERY.
   Expand/Normal switch to NORMAL.

3. Apply a suitable signal to give a V.S.W.R. reading of 1 on the normal scale.
4. Set Expand/Normal switch to EXPAND.
5. Check that a V.S.W.R. reading of 1 is obtained on the EXPAND scale, adjust RV3 if necessary.
6. Set Expand/Normal switch to NORMAL.
7. Adjust input to give a V.S.W.R. reading of 1.3 on the normal scale.
8. Set Expand/Normal switch to EXPAND.
9. Check that a reading of 1.3 $\pm$1% f.s.d. is obtained on the expand scale, adjust RV4 if necessary.

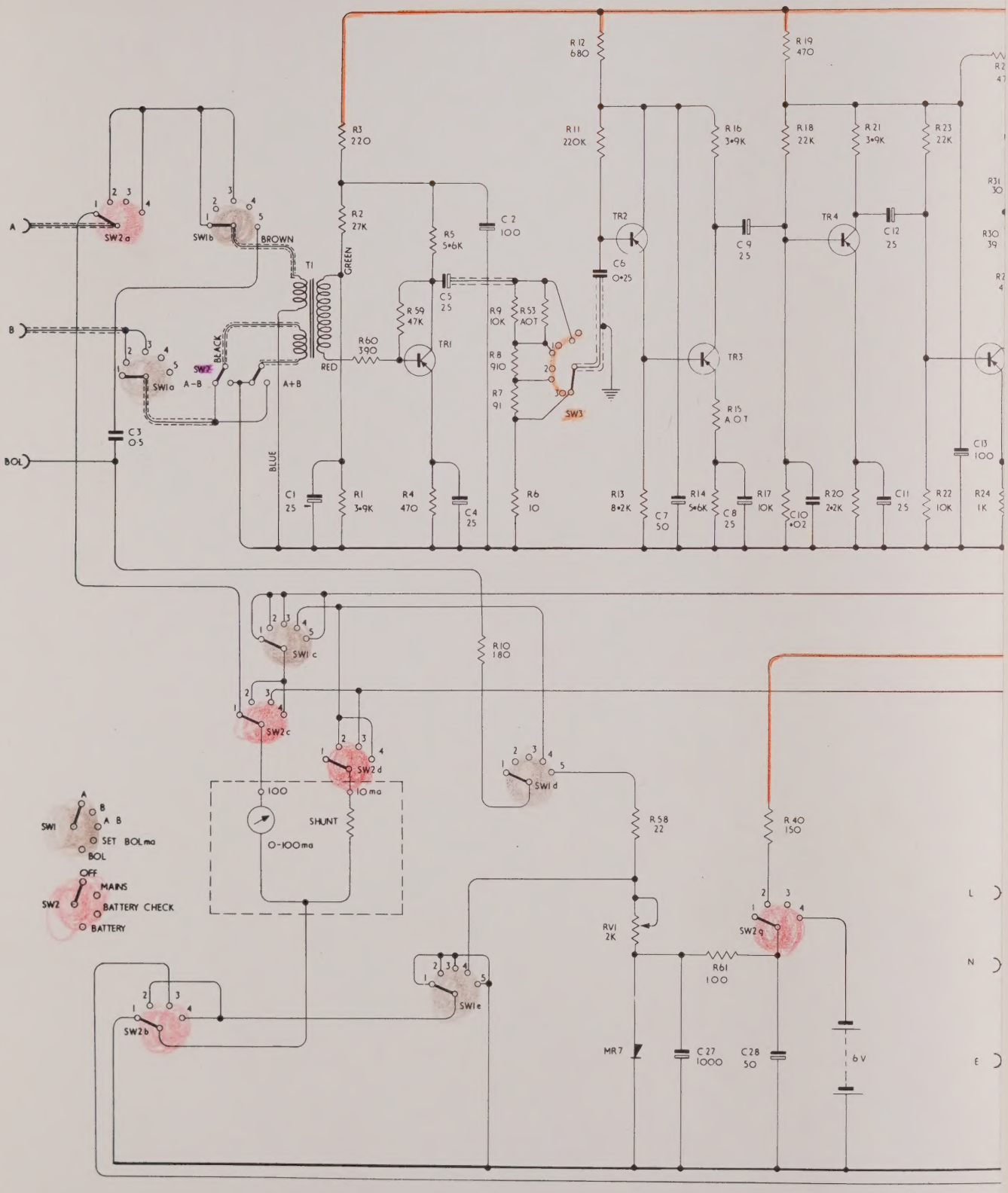
Progressive adjustment of RV3 and RV4 may be necessary to obtain correct results. If the correct settings cannot be obtained the instrument must be re-calibrated:-

10. Remove link between RV3 and R50.
11. Set controls as follows:-

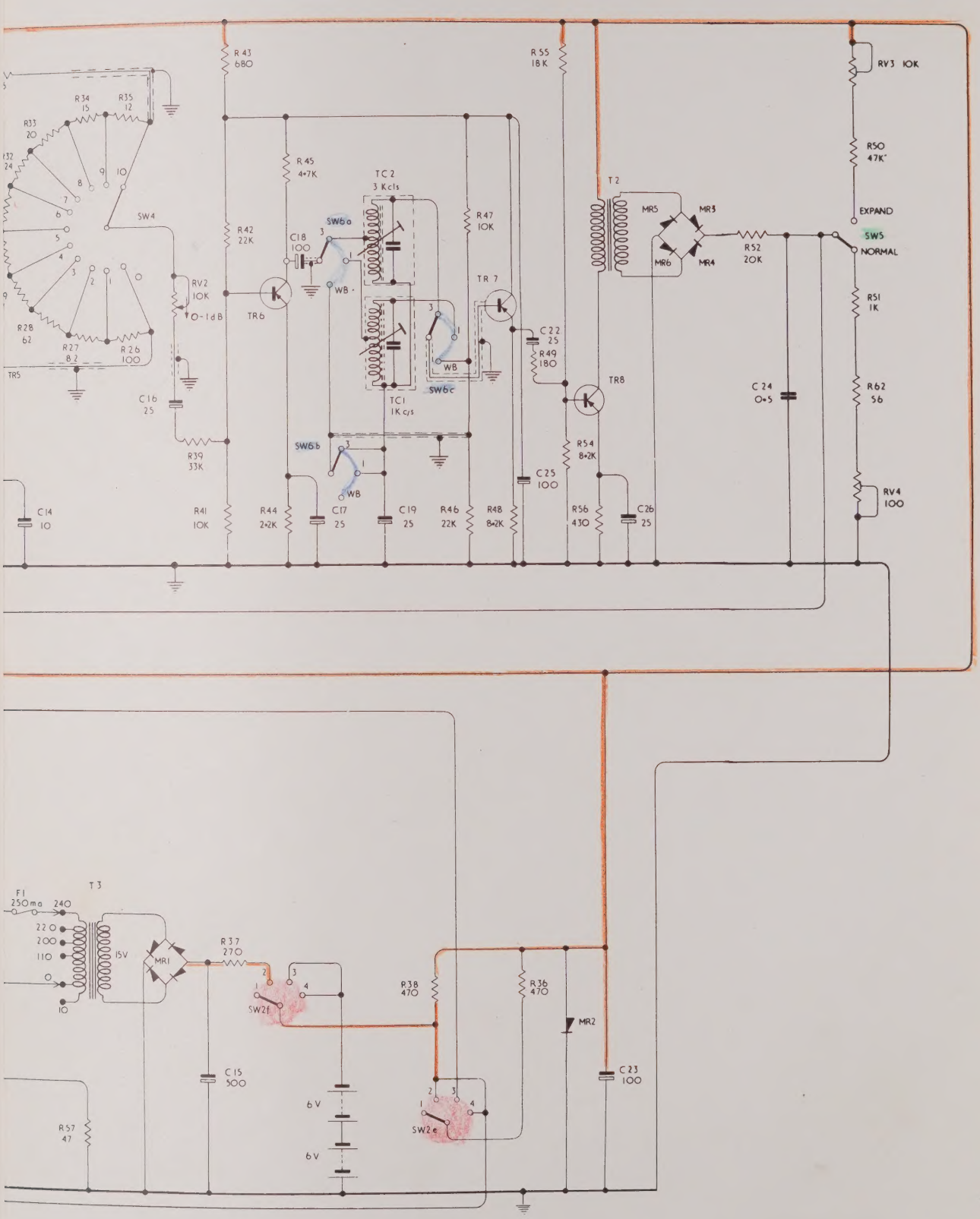
    Attenuators to 20dB.
    Frequency Selector to WIDE BAND.
    Input Selector to A.
    Supply Selector to MAINS or BATTERY.
    Expand/Normal switch to EXPAND.

12. Apply a 2 Kc/s signal to input A and adjust level to give a reading of 90 on the response scale.
13. Set Expand/Normal switch to NORMAL.
14. Adjust RV4 to give a reading of 34 on the response scale.
15. Reconnect link between RV3 and R50.

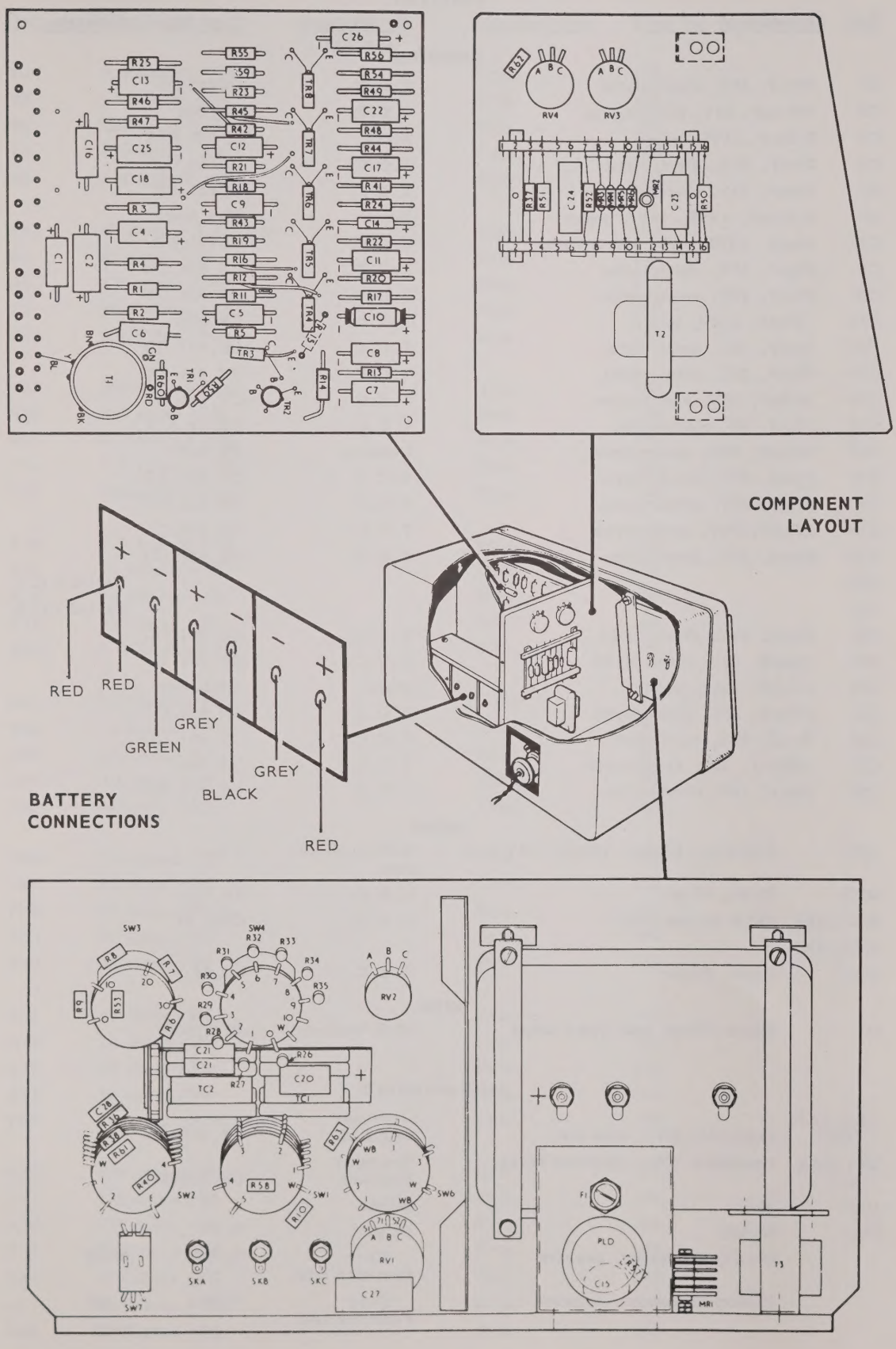
Then, proceed as in Items 1 to 9.



CIRCUIT FOR V.S.W.R. INDICATO



R AND SELECTIVE AMPLIFIER


RED
RED
GREY
GREEN
GREY
BLACK
RED
BATTERY CONNECTIONS
COMPONENT LAYOUT

PARTS LIST

Ref:	Component	Manufacturer	Type No.	Remarks
	CAPACITORS			
C1	25mF, 25V, electrolytic	T.C.C.	CE431 CD	
C2	100 mF, 25V, electrolytic	T.C.C.	CE434C	
C3	0.5mF, 150V, paper	Hunts	A.302.W48	
C4	25mF, 25V, electrolytic	T.C.C.	CE431.CD	
C5	25mF, 25V, electrolytic	T.C.C.	CE431.CD	
C6	0.25mF, ±20%, 150V, paper	Hunts	W48, A301	
C7	50mF, ±20%, 12V, electrolytic	T.C.C.	CE431.RD	
C8	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C9	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C10	.02mF, 350V, paper	T.C.C.	CP.33N	
C11	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C12	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C13	100mF, 25V, electrolytic	T.C.C.	CE.434.C	
C14	10mF, 3V, electrolytic	T.C.C.	CE.68.A.A.	
C15	500mF, 25V, electrolytic	Dubilier	BR.5020	
C16	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C17	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C18	100mF, 25V, electrolytic	T.C.C.	CE.434.C	
C19	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C20				Part of T.C.1.
C21				Part of T.C.2.
C22	25mF, 25V, electrolytic	T.C.C.	CE.431.OD	
C23	100mF, 25V, electrolytic	T.C.C.	CE.434.C.	
C24	0.5mF, 150V, paper	Hunts	A302.W48	
C25	100mF, 25V, electrolytic	T.C.C.	CE.434.C	
C26	25mF, 25V, electrolytic	T.C.C.	CE.431.CD	
C27	1000mF, 12V, electrolytic	T.C.C.	CE.90B	
C28	50mF, 12V, electrolytic	T.C.C.	CE.431.BD	
	DIODES			
MR1	Rectifier, bridge, 500mA, 12V d.c.	Salford Elect. Inst.	½ A	
MR2	Diode, Zener	G.E.C.	SX.75	
MR3, MR4	Diode germanium	G.E.C.	CEX.23	
MR5, MR6				
MR7	Diode, Zener	G.E.C.	SX.47	
	METER			
M1	Meter 100mA with 10mA shunt	W.H.Sanders	B619/010	
	PLUGS AND SOCKETS			
PLA, PLB, PLC	Connector BNC, free play	Greenpar Eng. Ltd.	CE.35070.C	
SKA, SKB, SKC	Connector BNC, bulkhead socket	Greenpar Eng. Ltd.	CE.35063	
PLD	Plug	Bulgin	P.73	
SKD	Socket	Bulgin	P.73	
	Battery connector, positive	Carr Fastener Ltd.	75/946	3-off
	Battery connector, negative	Carr Fastener Ltd.	75/945	3-off

Ref:	Component	Manufacturer	Type No.	Remarks
	RESISTORS			
R1	3.9 Kohms ±5%	Erie.	109.	
R2	27 Kohms ±5%	Erie.	109.	
R3	220 ohms ±5%	Erie.	109.	
R4	470 ohms ±2%	Erie.	109.	
R5	5.6 Kohms ±5%	Erie.	109.	
R6	10 ohms ±0.25 ohm	Erie.	109.	
R7	91 ohms ±1%	Erie.	109.	
R8	910 ohms ±1%	Erie.	109.	
R9	10 K ohms ±5%	Erie.	109.	
R10	180 ohms ±5%	Erie.	109.	
R11	220 Kohms ±5%	Erie.	109.	
R12	680 ohms ±5%	Erie.	109.	
R13	8.2 Kohms ±5%	Erie.	109.	
R14	5.6 Kohms ±5%	Erie.	109.	
R15	Adjusted on test	Erie.	109.	
R16	3.9 Kohms ±5%	Erie.	109.	
R17	10 Kohms ±5%	Erie.	109.	
R18	22 Kohms ±5%	Erie.	109.	
R19	470 ohms ±5%	Erie.	109.	
R20	1.2 Kohms ±5%	Erie.	109.	
R21	3.9 Kohms ±5%	Erie.	109.	
R22	10 Kohms ±5%	Erie.	109.	
R23	22 Kohms ±5%	Erie.	109.	
R24	1 Kohms ±5%	Erie.	109.	
R25	47 ohms ±2%	Erie.	109.	
R26	100 ohms ±2%	Erie.	109.	
R27	82 ohms ±2%	Erie.	109.	
R28	62 ohms ±2%	Erie.	109.	
R29	47 ohms ±2%	Erie.	109.	
R30	39 ohms ±2%	Erie.	109.	
R31	30 ohms ±2%	Erie.	109.	
R32	24 ohms ±2%	Erie.	109.	
R33	20 ohms ±2%	Erie.	109.	
R34	15 ohms ±2%	Erie.	109.	
R35	12 ohms ±0.24 ohms.	Erie.	109.	
R36	470 ohms ±2%	Erie.	109.	
R37	270 ohms ±2%	Erie.	109.	
R38	470 ohms ±2%	Erie.	109.	
R39	33 Kohms ±2%	Erie.	109.	
R40	150 ohms ±5%	Erie.	109.	
R41	10 Kohms ±5%	Erie.	109.	
R42	22 Kohms ±5%	Erie.	109.	

Ref:	Component	Manufacturer	Type No.	Remarks
R43	680 ohms ±5%	Erie.	109.	
R44	2.2 Kohms ±5%	Erie.	109.	
R45	4.7 Kohms ±5%	Erie.	109.	
R46	22 Kohms ±5%	Erie.	109.	
R47	10 Kohms ±5%	Erie.	109.	
R48	8.2 Kohms ±5%	Erie.	109.	
R49	180 ohms ±5%	Erie.	109.	
R50	47 Kohms ±2%	Erie.	109.	
R51	1 Kohm ±2%	Erie.	109.	
R52	20 Kohms ±5%	Erie.	109.	
R53	Adjusted on test.	Erie.	109.	
R54	8.2 Kohms ±5%	Erie.	109.	
R55	18 Kohms ±5%	Erie.	109.	
R56	430 ohms ±5%	Erie.	109.	
R57	47 ohms ±2%	Erie.	109.	
R58	22 ohms ±5%	Erie.	109.	
R59	47 Kohms ±5%	Erie.	109.	
R60	390 ohms ±5%	Erie.	109.	
R61	100 ohms ±5%	Erie.	109.	
R62	56 ohms ±2%	Erie.	109.	
R63	2.2 Kohms ±5%	Erie.	109.	

VARIABLE RESISTORS

RV1	2 Kohms ±10%, linear, wirewound.	Colvern	CLR. 901C
RV2	10 Kohms ±10%, linear, wirewound.	Colvern	CLR. 1106/11
RV3	10 Kohms ±10%, linear, wirewound.	Colvern	CLR. 1106/11S
RV4	100 ohm ±10%, linear, wirewound.	Colvern	CLR. 1106/11S

SWITCHES

SW1	Wafer switch	W. H. Sanders	B3619/021
SW2	Wafer switch	W. H. Sanders	B3619/022
SW3	Wafer switch	W. H. Sanders	B3619/023
SW4	Wafer switch	W. H. Sanders	B3619/024
SW5	Toggle switch, 1 pole, 2 way	Bulgin	S601/PD
SW6	Wafer switch	W. H. Sanders	B3619/026
SW7	Toggle Switch, 2 pole, c/o	Bulgin	S270/PD

TRANSFORMERS

T1	Input Transformer	The Belclere Co. Ltd.	EX. 2724
T2	Output Transformer	"	KN. 2340
T3	Mains Transformer	Willesden Transformer Co.	23

TUNED CIRCUITS

TC1	Tuned circuit assembly, 1 K c/s	W. H. Sanders	B3619/036
TC2	Tuned circuit assembly, 3 K c/s	W. H. Sanders	B3619/037

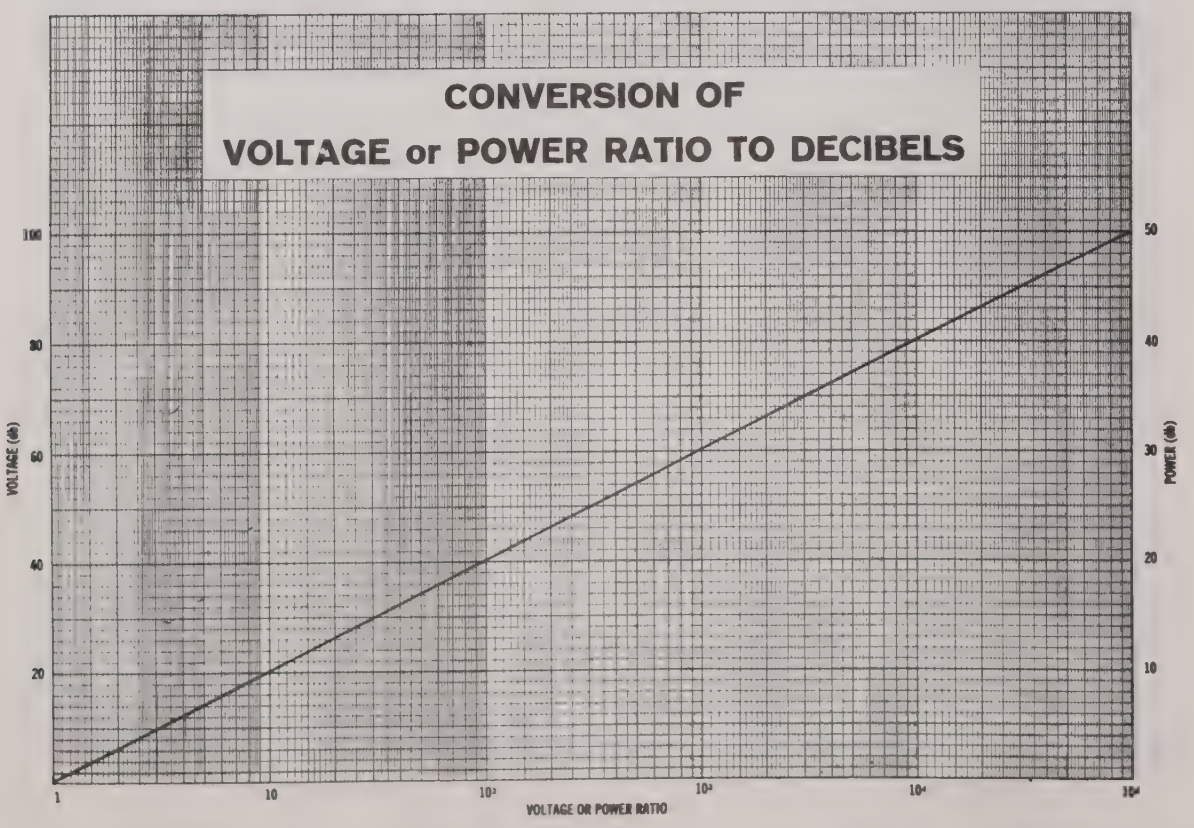
Ref:	Component	Manufacturer	Type No.	Remarks
		TRANSISTORS		
TR1, TR2	Silicon transistor	Texas Inst.	2S.302	
TR3, TR4	Silicon transistor	Mullard	BCZ.11	
TR5, TR6				
TR7, TR8				
		FUSE		
F1	Fuse link, 250mA, size 00	Belling-Lee	L.562	
	Control Knobs	**CONTROL KNOBS**		
1	Knob, black	Bulgin	K.360	Modified to W.H.S. D3619/001/34 6-off
		BATTERIES		
B1, B2, B3	Battery, dry, 6V.	Vidor	T.6001	

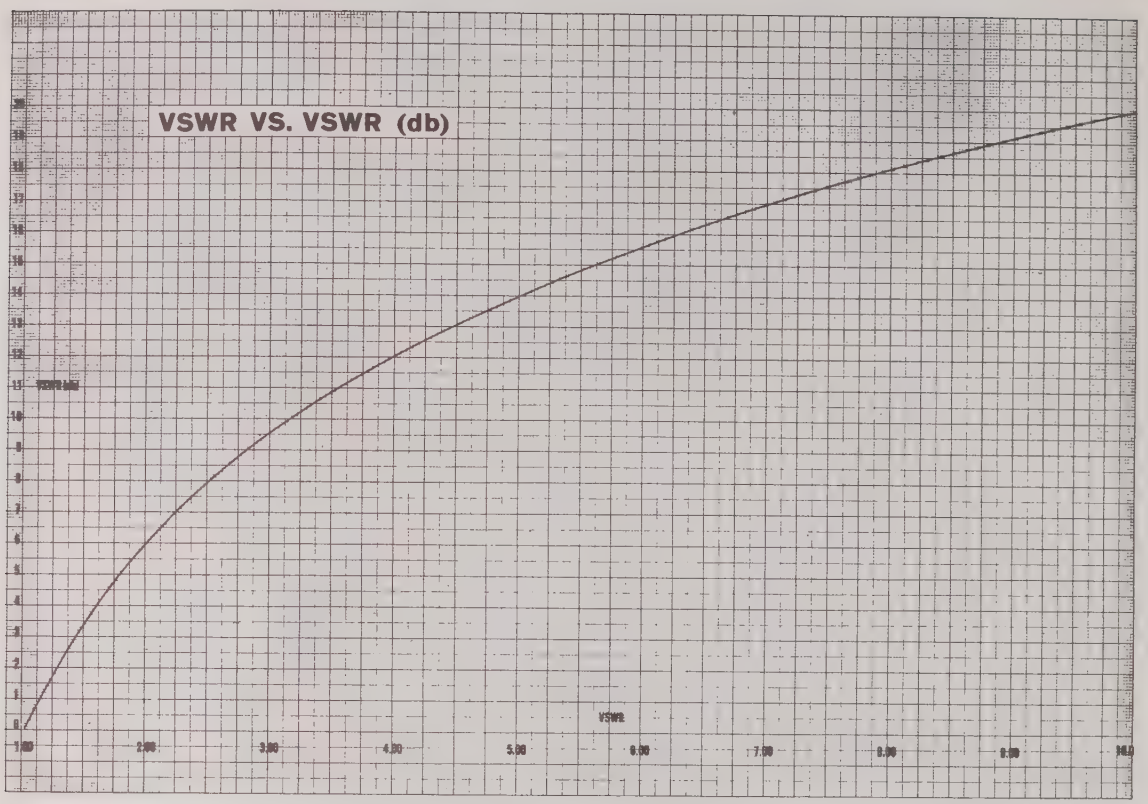
REPAIR

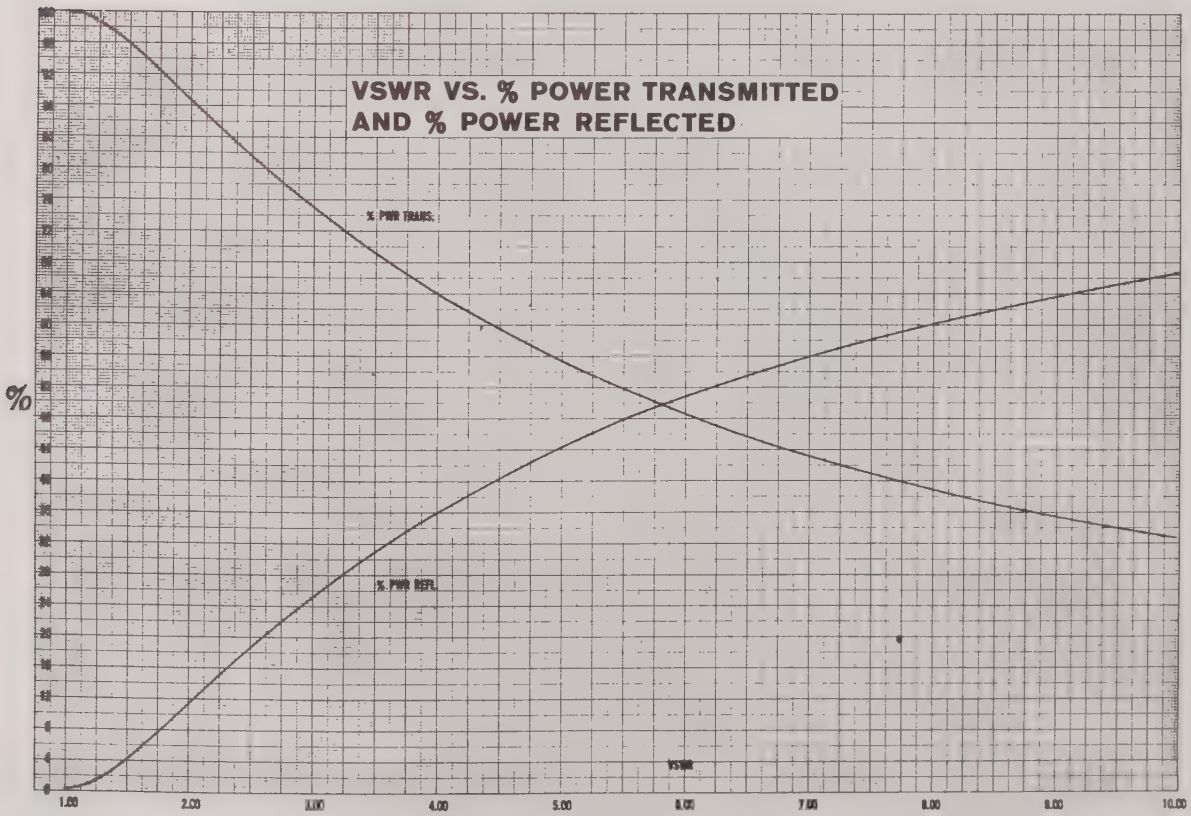
In general, replacement components may be ordered from the manufacturer or from W. H. Sanders. However, where a drawing number is quoted the component should be ordered from this company.

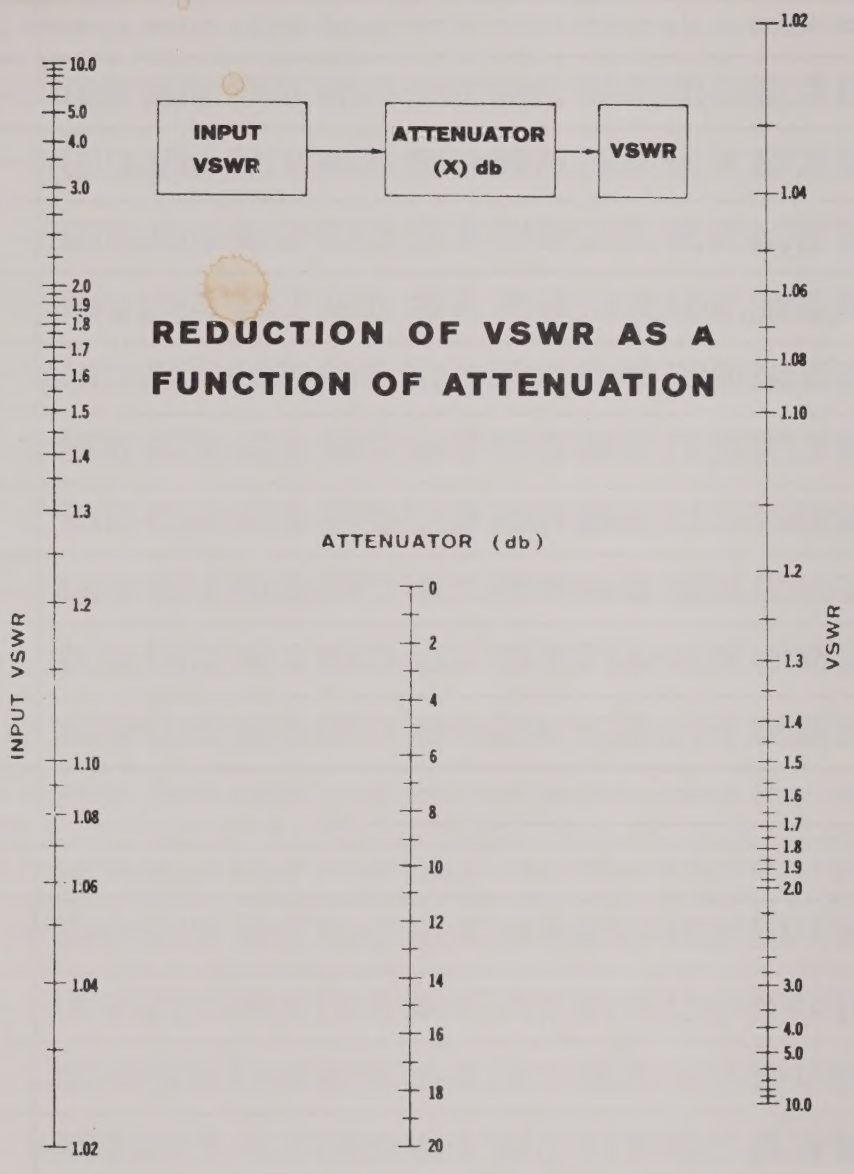
Enquiries should be made to:-

Commercial Office,
W. H. Sanders (Electronics) Ltd.
Gunnels Wood Road,
STEVENAGE, Hertfordshire, England.




VSWR VS. VSWR (db)
VSWR
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00


VSWR VS. % POWER TRANSMITTED
AND % POWER REFLECTED
% PWR TRANS.
% PWR REFL.
%
VSWR
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00



The Input V.S.W.R. resulting from the insertion of attenuation is found by laying a straight-edge from the original V.S.W.R. to the attenuator value and reading-off on the left hand scale.

V.S.W.R. (<1) TO POWER REFLECTION COEFFICIENT

s	0	1	2	3	4	5	6	7	8	9	s
.00	1.000	.9960	.9920	.9881	.9841	.9802	.9763	.9724	.9685	.9646	.00
.01	.9608	.9570	.9531	.9493	.9455	.9418	.9380	.9343	.9305	.9268	.01
.02	.9231	.9194	.9158	.9121	.9085	.9048	.9102	.8976	.8940	.8905	.02
.03	.8869	.8833	.8798	.8763	.8728	.8693	.8658	.8624	.8589	.8555	.03
.04	.8521	.8487	.8453	.8419	.8385	.8352	.8318	.8285	.8252	.8219	.04
.05	.8186	.8153	.8121	.8088	.8056	.8023	.7991	.7959	.7927	.7896	.05
.06	.7864	.7833	.7801	.7770	.7739	.7708	.7677	.7646	.7615	.7585	.06
.07	.7554	.7524	.7494	.7464	.7434	.7404	.7374	.7345	.7315	.7286	.07
.08	.7257	.7227	.7198	.7169	.7141	.7112	.7083	.7055	.7026	.6998	.08
.09	.6970	.6942	.6914	.6886	.6858	.6831	.6803	.6776	.6749	.6721	.09
.10	.6694	.6667	.6640	.6614	.6587	.6560	.6534	.6507	.6481	.6455	.10
.11	.6429	.6403	.6377	.6351	.6326	.6300	.6275	.6249	.6224	.6199	.11
.12	.6174	.6149	.6124	.6099	.6074	.6049	.6025	.6000	.5976	.5952	.12
.13	.5928	.5904	.5880	.5856	.5832	.5808	.5785	.5761	.5738	.5714	.13
.14	.5691	.5668	.5645	.5622	.5599	.5576	.5553	.5531	.5508	.5486	.14
.15	.5463	.5441	.5419	.5397	.5374	.5352	.5331	.5309	.5287	.5265	.15
.16	.5244	.5222	.5201	.5180	.5158	.5137	.5116	.5095	.5074	.5053	.16
.17	.5033	.5012	.4991	.4971	.4950	.4930	.4910	.4889	.4869	.4849	.17
.18	.4829	.4809	.4789	.4770	.4750	.4730	.4711	.4691	.4672	.4652	.18
.19	.4633	.4614	.4595	.4576	.4557	.4538	.4519	.4500	.4482	.4463	.19
.20	.4444	.4426	.4408	.4389	.4371	.4353	.4335	.4317	.4299	.4281	.20
.21	.4263	.4245	.4227	.4210	.4192	.4174	.4157	.4139	.4122	.4105	.21
.22	.4088	.4071	.4053	.4036	.4019	.4003	.3986	.3969	.3952	.3936	.22
.23	.3919	.3902	.3886	.3870	.3853	.3837	.3821	.3805	.3789	.3773	.23
.24	.3757	.3741	.3725	.3709	.3693	.3678	.3662	.3646	.3631	.3615	.24
.25	.3600	.3585	.3569	.3554	.3539	.3524	.3509	.3494	.3479	.3464	.25
.26	.3449	.3435	.3420	.3405	.3391	.3376	.3361	.3347	.3333	.3318	.26
.27	.3304	.3290	.3276	.3262	.3247	.3233	.3219	.3206	.3192	.3178	.27
.28	.3164	.3150	.3137	.3123	.3110	.3096	.3083	.3069	.3056	.3043	.28
.29	.3029	.3016	.3003	.2990	.2977	.2964	.2951	.2938	.2925	.2912	.29
.30	.2899	.2887	.2874	.2861	.2849	.2836	.2824	.2811	.2799	.2787	.30
.31	.2774	.2762	.2750	.2738	.2726	.2714	.2702	.2690	.2678	.2666	.31
.32	.2654	.2642	.2630	.2619	.2607	.2595	.2584	.2572	.2561	.2549	.32
.33	.2538	.2526	.2515	.2504	.2493	.2481	.2470	.2459	.2448	.2437	.33
.34	.2426	.2415	.2404	.2393	.2382	.2372	.2361	.2350	.2340	.2329	.34
.35	.2318	.2308	.2297	.2287	.2276	.2266	.2256	.2245	.2235	.2225	.35
.36	.2215	.2204	.2194	.2184	.2174	.2164	.2154	.2144	.2134	.2125	.36
.37	.2115	.2105	.2095	.2085	.2076	.2066	.2057	.2047	.2037	.2028	.37
.38	.2019	.2009	.2000	.1990	.1981	.1972	.1963	.1953	.1944	.1935	.38
.39	.1926	.1917	.1908	.1899	.1890	.1881	.1872	.1863	.1854	.1846	.39
.40	.1837	.1828	.1819	.1811	.1802	.1793	.1785	.1776	.1768	.1759	.40
.41	.1751	.1743	.1734	.1726	.1718	.1709	.1701	.1693	.1685	.1676	.41
.42	.1668	.1660	.1652	.1644	.1636	.1628	.1620	.1612	.1605	.1597	.42
.43	.1589	.1581	.1573	.1566	.1558	.1550	.1543	.1535	.1527	.1520	.43
.44	.1512	.1505	.1497	.1490	.1483	.1475	.1468	.1461	.1453	.1446	.44
.45	.1439	.1432	.1424	.1417	.1410	.1403	.1396	.1389	.1382	.1375	.45
.46	.1368	.1361	.1354	.1347	.1340	.1334	.1327	.1320	.1313	.1307	.46
.47	.1300	.1293	.1287	.1280	.1273	.1267	.1260	.1254	.1247	.1241	.47
.48	.1235	.1228	.1222	.1215	.1209	.1203	.1196	.1190	.1184	.1178	.48
.49	.1172	.1165	.1159	.1153	.1147	.1141	.1135	.1129	.1123	.1117	.49
s	0	1	2	3	4	5	6	7	8	9	s

s	0	1	2	3	4	5	6	7	8	9	s
.50	.1111	.1105	.1099	.1093	.1088	.1082	.1076	.1070	.1065	.1059	.50
.51	.1053	.1047	.1042	.1036	.1030	.1025	.1019	.1014	.1008	.1003	.51
.52	.0997	.0992	.0986	.0981	.0976	.0970	.0965	.0960	.0954	.0949	.52
.53	.0944	.0938	.0933	.0928	.0923	.0918	.0913	.0907	.0902	.0897	.53
.54	.0892	.0887	.0882	.0877	.0872	.0867	.0862	.0858	.0853	.0848	.54
.55	.0843	.0838	.0833	.0829	.0824	.0819	.0814	.0810	.0805	.0800	.55
.56	.0796	.0791	.0786	.0782	.0777	.0773	.0768	.0764	.0759	.0755	.56
.57	.0750	.0746	.0741	.0737	.0733	.0728	.0724	.0720	.0715	.0711	.57
.58	.0707	.0702	.0698	.0694	.0690	.0686	.0681	.0677	.0673	.0669	.58
.59	.0665	.0661	.0657	.0653	.0649	.0645	.0641	.0637	.0633	.0629	.59
.60	.0625	.0621	.0617	.0613	.0610	.0606	.0602	.0598	.0594	.0591	.60
.61	.0587	.0583	.0579	.0576	.0572	.0568	.0565	.0561	.0557	.0554	.61
.62	.0550	.0547	.0543	.0540	.0536	.0533	.0529	.0526	.0522	.0519	.62
.63	.0515	.0512	.0509	.0505	.0502	.0498	.0495	.0492	.0488	.0485	.63
.64	.0482	.0479	.0475	.0472	.0469	.0466	.0463	.0459	.0456	.0453	.64
.65	.0450	.0447	.0444	.0441	.0438	.0435	.0432	.0429	.0426	.0423	.65
.66	.0420	.0417	.0414	.0411	.0408	.0405	.0402	.0399	.0396	.0393	.66
.67	.0391	.0388	.0385	.0382	.0379	.0377	.0374	.0371	.0368	.0366	.67
.68	.0363	.0360	.0357	.0355	.0352	.0350	.0347	.0344	.0342	.0339	.68
.69	.0337	.0334	.0331	.0329	.0326	.0324	.0321	.0319	.0316	.0314	.69
.70	.0311	.0309	.0307	.0304	.0302	.0299	.0297	.0295	.0292	.0290	.70
.71	.0288	.0285	.0283	.0281	.0278	.0276	.0274	.0272	.0269	.0267	.71
.72	.0265	.0263	.0261	.0259	.0256	.0254	.0252	.0250	.0248	.0246	.72
.73	.0244	.0242	.0239	.0237	.0235	.0233	.0231	.0229	.0227	.0225	.73
.74	.0223	.0221	.0219	.0217	.0216	.0214	.0212	.0210	.0208	.0206	.74
.75	.0204	.0202	.0200	.0199	.0197	.0195	.0193	.0191	.0190	.0188	.75
.76	.0186	.0184	.0182	.0181	.0179	.0177	.0176	.0174	.0172	.0171	.76
.77	.0169	.0167	.0166	.0164	.0162	.0161	.0159	.0158	.0156	.0154	.77
.78	.0153	.0151	.0150	.0148	.0147	.0145	.0144	.0142	.0141	.0139	.78
.79	.0138	.0136	.0135	.0133	.0132	.0130	.0129	.0128	.0126	.0125	.79
.80	.0124	.0122	.0121	.0119	.0118	.0117	.0115	.0114	.0113	.0112	.80
.81	.0110	.0109	.0108	.0106	.0105	.0104	.0103	.0101	.0100	.0099	.81
.82	.0098	.0097	.0095	.0094	.0093	.0092	.0091	.0090	.0089	.0087	.82
.83	.0086	.0085	.0084	.0083	.0082	.0081	.0080	.0079	.0078	.0077	.83
.84	.0076	.0075	.0074	.0073	.0072	.0071	.0070	.0069	.0068	.0067	.84
.85	.0066	.0065	.0064	.0063	.0062	.0061	.0060	.0059	.0058	.0058	.85
.86	.0057	.0056	.0055	.0054	.0053	.0052	.0052	.0051	.0050	.0049	.86
.87	.0048	.0048	.0047	.0046	.0045	.0044	.0044	.0043	.0042	.0042	.87
.88	.0041	.0040	.0039	.0039	.0038	.0037	.0037	.0036	.0035	.0035	.88
.89	.0034	.0033	.0033	.0032	.0031	.0031	.0030	.0030	.0029	.0028	.89
.90	.0028	.0027	.0027	.0026	.0025	.0025	.0024	.0024	.0023	.0023	.90
.91	.0022	.0022	.0021	.0021	.0020	.0020	.0019	.0019	.0018	.0018	.91
.92	.0017	.0017	.0017	.0016	.0016	.0015	.0015	.0014	.0014	.0014	.92
.93	.0013	.0013	.0012	.0012	.0012	.0011	.0011	.0011	.0010	.0010	.93
.94	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0007	.0007	.0007	.94
.95	.0007	.0006	.0006	.0006	.0006	.0005	.0005	.0005	.0005	.0004	.95
.96	.0004	.0004	.0004	.0004	.0003	.0003	.0003	.0003	.0003	.0003	.96
.97	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0001	.0001	.0001	.97
.98	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0000	.0000	.0000	.98
.99	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.99
s	0	1	2	3	4	5	6	7	8	9	s

V.S.W.R. (<1) TO VOLTAGE REFLECTION COEFFICIENT

s	0	1	2	3	4	5	6	7	8	9	s
.00	1.000	.9980	.9960	.9940	.9920	.9901	.9881	.9861	.9841	.9822	.00
.01	.9802	.9782	.9763	.9743	.9724	.9704	.9685	.9666	.9646	.9627	.01
.02	.9608	.9589	.9570	.9550	.9531	.9512	.9493	.9474	.9455	.9436	.02
.03	.9418	.9399	.9380	.9361	.9342	.9324	.9305	.9286	.9268	.9249	.03
.04	.9231	.9212	.9194	.9176	.9157	.9139	.9121	.9102	.9084	.9066	.04
.05	.9048	.9030	.9011	.8993	.8975	.8957	.8939	.8922	.8904	.8886	.05
.06	.8868	.8850	.8832	.8815	.8797	.8779	.8762	.8744	.8727	.8709	.06
.07	.8692	.8674	.8657	.8639	.8622	.8605	.8587	.8570	.8553	.8536	.07
.08	.8519	.8501	.8484	.8467	.8450	.8433	.8416	.8399	.8382	.8366	.08
.09	.8349	.8332	.8315	.8298	.8282	.8265	.8248	.8232	.8215	.8198	.09
.10	.8182	.8165	.8149	.8132	.8116	.8100	.8083	.8067	.8051	.8034	.10
.11	.8018	.8002	.7986	.7970	.7953	.7937	.7921	.7905	.7889	.7873	.11
.12	.7857	.7841	.7825	.7809	.7794	.7778	.7762	.7746	.7731	.7715	.12
.13	.7699	.7684	.7668	.7652	.7637	.7621	.7606	.7590	.7575	.7559	.13
.14	.7544	.7529	.7513	.7498	.7483	.7467	.7452	.7437	.7422	.7406	.14
.15	.7391	.7376	.7361	.7346	.7331	.7316	.7301	.7286	.7271	.7256	.15
.16	.7241	.7227	.7212	.7197	.7182	.7167	.7153	.7138	.7123	.7109	.16
.17	.7094	.7079	.7065	.7050	.7036	.7021	.7007	.6992	.6978	.6964	.17
.18	.6949	.6935	.6921	.6906	.6892	.6878	.6863	.6849	.6835	.6821	.18
.19	.6807	.6793	.6779	.6765	.6750	.6736	.6722	.6708	.6695	.6681	.19
.20	.6667	.6653	.6639	.6625	.6611	.6598	.6584	.6570	.6556	.6543	.20
.21	.6529	.6515	.6502	.6488	.6475	.6461	.6447	.6434	.6420	.6407	.21
.22	.6393	.6380	.6367	.6353	.6340	.6327	.6313	.6300	.6287	.6273	.22
.23	.6260	.6247	.6234	.6221	.6208	.6194	.6181	.6168	.6155	.6142	.23
.24	.6129	.6116	.6103	.6090	.6077	.6064	.6051	.6039	.6026	.6013	.24
.25	.6000	.5987	.5974	.5962	.5949	.5936	.5924	.5911	.5898	.5886	.25
.26	.5873	.5860	.5848	.5835	.5823	.5810	.5798	.5785	.5773	.5760	.26
.27	.5748	.5736	.5723	.5711	.5699	.5686	.5674	.5662	.5650	.5637	.27
.28	.5625	.5613	.5601	.5589	.5576	.5564	.5552	.5540	.5528	.5516	.28
.29	.5504	.5492	.5480	.5468	.5456	.5444	.5432	.5420	.5408	.5397	.29
.30	.5385	.5373	.5361	.5349	.5337	.5326	.5314	.5302	.5291	.5279	.30
.31	.5267	.5256	.5244	.5232	.5221	.5209	.5198	.5186	.5175	.5163	.31
.32	.5152	.5140	.5129	.5117	.5106	.5094	.5083	.5072	.5060	.5049	.32
.33	.5038	.5026	.5015	.5004	.4993	.4981	.4970	.4959	.4948	.4937	.33
.34	.4925	.4914	.4903	.4892	.4881	.4870	.4859	.4848	.4837	.4826	.34
.35	.4815	.4804	.4793	.4782	.4771	.4760	.4749	.4738	.4728	.4717	.35
.36	.4706	.4695	.4684	.4674	.4663	.4652	.4641	.4631	.4620	.4609	.36
.37	.4599	.4588	.4577	.4567	.4556	.4546	.4535	.4524	.4514	.4503	.37
.38	.4493	.4482	.4472	.4461	.4451	.4440	.4430	.4420	.4409	.4399	.38
.39	.4389	.4378	.4368	.4358	.4347	.4337	.4327	.4316	.4306	.4296	.39
.40	.4286	.4276	.4265	.4255	.4245	.4235	.4225	.4215	.4205	.4195	.40
.41	.4184	.4174	.4164	.4154	.4144	.4134	.4124	.4114	.4104	.4094	.41
.42	.4085	.4075	.4065	.4055	.4045	.4035	.4025	.4015	.4006	.3996	.42
.43	.3986	.3976	.3967	.3957	.3947	.3937	.3928	.3918	.3908	.3899	.43
.44	.3889	.3879	.3870	.3860	.3850	.3841	.3831	.3822	.3812	.3803	.44
.45	.3793	.3784	.3774	.3765	.3755	.3746	.3736	.3727	.3717	.3708	.45
.46	.3699	.3689	.3680	.3671	.3661	.3652	.3643	.3633	.3624	.3615	.46
.47	.3605	.3596	.3587	.3578	.3569	.3559	.3550	.3541	.3532	.3523	.47
.48	.3514	.3504	.3495	.3486	.3477	.3468	.3459	.3450	.3441	.3432	.48
.49	.3423	.3414	.3405	.3396	.3387	.3378	.3369	.3360	.3351	.3342	.49

s	0	1	2	3	4	5	6	7	8	9	s
.50	.3333	.3325	.3316	.3307	.3298	.3289	.3280	.3271	.3263	.3254	.50
.51	.3245	.3236	.3228	.3219	.3210	.3201	.3193	.3184	.3175	.3167	.51
.52	.3158	.3149	.3141	.3132	.3123	.3115	.3106	.3098	.3089	.3080	.52
.53	.3072	.3063	.3055	.3046	.3038	.3029	.3021	.3012	.3004	.2996	.53
.54	.2987	.2979	.2970	.2962	.2953	.2945	.2937	.2928	.2920	.2912	.54
.55	.2903	.2895	.2887	.2878	.2870	.2862	.2854	.2845	.2837	.2829	.55
.56	.2821	.2812	.2804	.2796	.2788	.2780	.2771	.2763	.2755	.2747	.56
.57	.2739	.2731	.2723	.2715	.2707	.2698	.2690	.2682	.2674	.2666	.57
.58	.2658	.2650	.2642	.2634	.2626	.2618	.2610	.2602	.2595	.2587	.58
.59	.2579	.2571	.2563	.2555	.2547	.2539	.2531	.2524	.2516	.2508	.59
.60	.2500	.2492	.2484	.2477	.2469	.2461	.2453	.2446	.2438	.2430	.60
.61	.2422	.2415	.2407	.2399	.2392	.2384	.2376	.2369	.2361	.2353	.61
.62	.2346	.2338	.2331	.2323	.2315	.2308	.2300	.2293	.2285	.2278	.62
.63	.2270	.2262	.2255	.2247	.2240	.2232	.2225	.2218	.2210	.2203	.63
.64	.2195	.2188	.2180	.2173	.2166	.2158	.2151	.2143	.2136	.2129	.64
.65	.2121	.2114	.2107	.2099	.2092	.2085	.2077	.2070	.2063	.2056	.65
.66	.2048	.2041	.2034	.2027	.2019	.2012	.2005	.1998	.1990	.1983	.66
.67	.1976	.1969	.1962	.1955	.1947	.1940	.1933	.1926	.1919	.1912	.67
.68	.1905	.1898	.1891	.1884	.1877	.1869	.1862	.1855	.1848	.1841	.68
.69	.1834	.1827	.1820	.1813	.1806	.1799	.1793	.1786	.1779	.1772	.69
.70	.1765	.1758	.1751	.1744	.1737	.1730	.1723	.1717	.1710	.1703	.70
.71	.1696	.1689	.1682	.1675	.1669	.1662	.1655	.1648	.1641	.1635	.71
.72	.1628	.1621	.1614	.1608	.1601	.1594	.1588	.1581	.1574	.1567	.72
.73	.1561	.1554	.1547	.1541	.1534	.1527	.1521	.1514	.1508	.1501	.73
.74	.1494	.1488	.1481	.1475	.1468	.1461	.1455	.1448	.1442	.1435	.74
.75	.1429	.1422	.1416	.1409	.1403	.1396	.1390	.1383	.1377	.1370	.75
.76	.1364	.1357	.1351	.1344	.1338	.1331	.1325	.1319	.1312	.1306	.76
.77	.1299	.1293	.1287	.1280	.1274	.1268	.1261	.1255	.1249	.1242	.77
.78	.1236	.1230	.1223	.1217	.1211	.1205	.1198	.1192	.1186	.1179	.78
.79	.1173	.1167	.1161	.1155	.1148	.1142	.1136	.1130	.1124	.1117	.79
.80	.1111	.1105	.1099	.1093	.1087	.1080	.1074	.1068	.1062	.1056	.80
.81	.1050	.1044	.1038	.1031	.1025	.1019	.1013	.1007	.1001	.0995	.81
.82	.0989	.0983	.0977	.0971	.0965	.0959	.0953	.0947	.0941	.0935	.82
.83	.0929	.0923	.0917	.0911	.0905	.0899	.0893	.0887	.0881	.0876	.83
.84	.0870	.0864	.0858	.0852	.0846	.0840	.0834	.0828	.0823	.0817	.84
.85	.0811	.0805	.0799	.0793	.0788	.0782	.0776	.0770	.0764	.0759	.85
.86	.0753	.0747	.0741	.0735	.0730	.0724	.0718	.0712	.0707	.0701	.86
.87	.0695	.0690	.0684	.0678	.0672	.0667	.0661	.0655	.0650	.0644	.87
.88	.0638	.0633	.0627	.0621	.0616	.0610	.0605	.0599	.0593	.0588	.88
.89	.0582	.0576	.0571	.0565	.0560	.0554	.0549	.0543	.0537	.0532	.89
.90	.0526	.0521	.0515	.0510	.0504	.0499	.0493	.0488	.0482	.0477	.90
.91	.0471	.0466	.0460	.0455	.0449	.0444	.0438	.0433	.0428	.0422	.91
.92	.0417	.0411	.0406	.0400	.0395	.0390	.0384	.0379	.0373	.0368	.92
.93	.0363	.0357	.0352	.0347	.0341	.0336	.0331	.0325	.0320	.0315	.93
.94	.0309	.0304	.0299	.0293	.0288	.0283	.0278	.0272	.0267	.0262	.94
.95	.0256	.0251	.0246	.0241	.0235	.0230	.0225	.0220	.0215	.0209	.95
.96	.0204	.0199	.0194	.0189	.0183	.0178	.0173	.0168	.0163	.0157	.96
.97	.0152	.0147	.0142	.0137	.0132	.0127	.0122	.0116	.0111	.0106	.97
.98	.0101	.0096	.0091	.0086	.0081	.0076	.0071	.0065	.0060	.0055	.98
.99	.0050	.0045	.0040	.0035	.0030	.0025	.0020	.0015	.0010	.0005	.99

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